Design and Development of an Intelligent Tool to Assist Textile Designers

A

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1. INTRODUCTION

India, being a land of diverse cultures, has a very rich traditional textile background with multiple textures on handlooms, dyeing, weaving, surface embellishment, and multiple hand block printing techniques. The wide range of design and weave, specific to the region of their origin, are masterpieces enhanced by the skills of the specialist craftsmen and their traditions. Each region has its unique way of doing embroidery, resist dyeing, printing, and hand-weaving reflecting upon its culture, values, religious framework, etc. One of the fundamental duties of an Indian citizen, as envisaged in Article 51A of our Indian constitution, is 'To value and preserve the rich heritage of our composite culture'.

Embroidered Textiles are created using cotton, silk and woolen threads, or gold/silver to embroider on various media ranging from cotton, silk, woolen fabrics to velvet and leather. Kashida from Kashmir, Phulkari from Punjab, Chamba rumal from Himachal Pradesh, Gujarat, Parsi style of embroidery, Chikankari from Uttar Pradesh, Phool Patti ka Kaam from Uttar Pradesh, Zardozi from Uttar Pradesh, Kasuti from Karnataka, Lambada embroidery from Andhra Pradesh, Kantha from West Bengal, Sujani from Bihar, Pipli appliqué from Orissa are some of the famous embroidery styles. The motifs used, the techniques employed like the base material, types of threads, colors used, and the style of embroidery like aari style, etc. are indicative of the region where they originated from. For example, motifs used in the Kashida style of Kashmir depict the natural elements which include the rich flora and fauna of the region of Kashmir. Typical motifs are birds like a magpie, kingfisher; flowers, butterflies, maple leaves, almonds, cherries, grapes, and plums which are found abundantly in the Kashmir region. Resist dyed production technique as against embroidered varieties are also used in traditional textiles like Bandni of Gujarat, Bandhej (fabric resist-dyed) and Lehariya of Rajasthan, Patola of Gujarat, Bandhas of Odisha, Pochampally Ikats (yarn resist-dyed) of Andhra Pradesh. The origin of technique and the procedure again varies from region to region. Another technique employed in textile production is printing using hand-carved wooden blocks. Examples of printed textiles include Bagru & Sanganer prints of Rajasthan, Kalamkari prints from Andhra Pradesh, etc. Such is the huge variety and diversity of Indian textiles. As quoted in a book [1], "To write about Indian handicrafts and textiles is almost like writing about the country itself. So vast, complex, colorful, and yet with a simplicity and charm, difficult to attain under comparable conditions". Much lies in the hands of textile designers as to how they make creative designs

and at the same time adhering to the traditional motifs, techniques, and styles of the respective varieties of the regions.

Fashion designers try to contemporize traditional designs. The industry is caught in a changing landscape with two problems being most evident.

(i) The traditional design process is extremely skill oriented with the human worker being the designer and the implementor of the design as well. The designers have to learn the skills painstakingly and their productivity is pretty much limited with not much technical support. The art component is extremely high and the quality and quantity both depend on the individual designer concerned. Demand for larger variety is insatiable and individual designers find it hard to bring in more variety because of limited skills and training.

(ii) The onslaught of technology has made time to market the crucial deciding factor between success and failure. New designs have to be brought to market as fast as possible with the early bird getting the advantage in a winner takes all situation.

The traditional Indian designers must adapt quickly to these market realities to ensure that the beautiful art traditional forms are not only protected from extinction but also enhanced to give them their rightful place in the world of Textile design.

The present-day is an era of technology. Almost every Industrial sector is counting on the technological developments happening in their respective fields. The field of Textile Design is no exception. In the Textile field, to enhance the system of clothing designs and cater to the public's variable emotional prerequisites, designers need to discover fresh methods appropriate for clothing design. Technology is increasingly being utilized by designers for creating new designs and design editing. Software tools play an important role in these endeavors. Software technology interventions can be described at essentially four different levels in the textile industry. These are as follows.

(i) **Level I**: The simplest use of the software is for editing and storing designs in editable formats. A plethora of software tools are available that are being used for this purpose with Adobe Suite of tools and CorelDraw being some of the more popular ones. Most of these tools are essentially image creation and editing tools without being specific to the Textile industry. However, these tools aid the designers in conveniently storing and editing the designs. Libraries of designs and

design elements are available to make it easier and speed up the design process. In these endeavors, the main ideation and creativity are still of the designer. These tools are essentially drawing and visualization aids to express creativity. Facilities are available for easier transfer of their novel design ideas to media of their choice through the computer.

(ii) **Level II**: With the increasing use of software tools, designers have the facility to incorporate geometrical designs and mathematical artifacts in their designs easily to create a variety of designs. Software tools are available in different domains for aiding the design process by providing low-level elements along with facilities to combine them in specified patterns according to the mathematical algorithms invoked for the purpose. These tools vary widely in terms of their sophistication and the level of creativity enhancement that they provide by making it easier for the designers to express their ideas rapidly and visualize them on their screens for further refinement. The use of these tools cuts down the time required for each of the design – visualize – refine cycles providing rapid designs in shorter times which is the key for market success today.

(iii) **Level III**: The Level I tools are merely drawing and visualization aids and the Level II tools go a step further in providing some algorithmic assistance in the design process with the increased use of mathematics. Level III tools go a step further and facilitate semi-automatic design processes. The human designer is still in the loop. However, the level of assistance is enhanced. The designer can utilize the software tools to either retrieve relevant designs from an annotated database of existing designs or even generate different new designs with a minimum specification of design inputs according to the sophistication of the tool available. For example, the designer can specify the art elements that he or she wishes to include in the design, the colors, textures and other characteristics of the design and retrieve the designs that most closely match these specifications from an annotated database using algorithmic ideas referred to as Keyword Based Image Retrieval (KBIR) in the literature. Alternatively, the designer can draw a rough sketch and use image matching algorithms referred to as Content-Based Image Retrieval (CBIR) in the literature to retrieve the designs that are closest to the sketch. These help the designer in two ways. The retrieval of existing designs helps to avoid inadvertent design

duplication. Further, useful starting points for triggering creativity of the designer are provided to counter the so-called artists' “terror of the blank page”. This further speeds-up the design process and also potentially enhances the quality of designs produced by the same designer.

(iv) **Level IV**: The current trend in industries is towards more and more sophistication of design tools for increasingly automated design procedures aided by the developments in Artificial Intelligence (AI) and, more specifically, Machine Learning. The Textile Design industry is no exception. Efforts are being made to incorporate AI into tools specifically created for Textile Design towards more autonomy with very little intervention, if any, of the human designer. These again vary in the level of sophistication and the quality of designs produced. However, there are definite trends towards increasing sophistication auguring well for the future. This is a more recent phenomenon and currently considerable efforts are being made in this direction.

The rest of the synopsis document is organized as follows. The existing literature and tools about each of the four levels of technology interventions described above are reviewed in section 2. The work proposed in this research proposal is described in section 3.

2. Prior Art

In this section, the existing literature and tools are described briefly for all the 4 levels of software technology interventions mentioned in section 1.

2.1 Literature and tools pertaining to Level I

The tools pertaining to Level 1 are essentially drawing and drafting tools that make it easier for designers to express their creativity. All the benefits of computer editing like making design changes and seeing the effects without expending too much time and money, systematic storage and retrieval of designs for reuse, etc. are obtained with these tools.

Table 1: Level I tool

S. No	Tool Name	Open source/Paid	Target Users	Purpose	Stage
1	CHIC CAD	Open-source	1000 artisans from Kanpur-Lucknow region	1- To benefit the artisans by enabling the creation of new designs with quick turn around times. 2- To improve and conserve the Indian	Design

				heritage and its traditional crafts.	
2	CorelDRAW	Paid (15-days FREE TRIAL)	Fashion designers, architectural draftsmen, engineers, etc.	For creating logos, flexes, brochures, invitation cards, and any kind of vector designing.	Design & Printing
3	AutoCAD	Free for students Account	Architectural drawing of all kinds.	1-A Computer-aided tool to enable designers to create diverse kinds of drawings and designs. 2-To create designs much more quickly than by hand.	Design & Drafting
4	PatternSmith	Paid (30-day FREE TRIAL)	Bicycles, Automotive interiors, handbags, pool covers, and sporting goods.	An apparel management tool that provides apparel businesses with templates, 2D or 3D drafting, editing, and nesting solutions.	Pattern Drafting, Editing & Nesting
5	Adobe Illustrator	Paid (30-day FREE TRIAL)	Package Design, Emojis, Fashion, Motion Graphics, Wearable Devices, Video Game Development, 3D printed objects.	1-It is the standard for making logos, graphics, comics, fonts, and much more. 2-It is used for creating vector graphics for print or the web.	Design & Productivity
6	Adobe Textile Designer	Paid	Carpet design, Blankets, bed linens, or non-fabric materials like wallpaper and wrapping paper.	It provides tools for making repeating patterns, defining separations, and working with colorways. While keeping every element editable by Photoshop.	Designing & Printing
7	Pattern Maker Professional	Paid (30-day FREE TRIAL)	Clothing or Metal casting pattern used in foundries.	Windows application for the design of counted cross-stitch patterns.	Drawing, Editing, & Drafting
8	SmartDesigner	Paid (FREE TRIAL)	Small residential design firms, medium commercial firms, and large international hospitality firms use SmartDesign.	Creative designing solution for the fashion and related industries with features such as pattern making, coloring, vectors,	Design

				knit, and 3D designs and weaves.	
9	Evolution Textile Design	Paid	Clothing, bed linens, kitchen towels, carpets, and blankets, or non-fabric materials like wallpaper and wrapping paper.	Turnkey textile design software solution for designing and coloring.	Design
10	Valentina	Free/Open source	Design Industry	Used by small designers, individuals, small and medium-sized textile creators, and many in the garment industry.	Drafting
11	Sketch	A one-time licensing fee of US $99. Works only for MAC OSX.	Young and upcoming designers	An app with an intuitive interface and a broad array of plugins. More features than Adobe illustrator.	Design
12	Pantone Color Finder	FREE	Designers	Exports color values of a chosen photo	Design

There are many more on the list like Efi-Optitex, Creative Designer System, Browzwear, CLO 3D Fashion, EDraw Max, Wings Xp Embroidery Design, WeaveIT, Tailornova, Pattern Design software, etc. Every software tool is meant for a particular purpose & its application depends on the specific requirements in different fields.

2.2 Literature pertaining to Level II

Garment pattern designers have begun to focus on science, technology, and mathematics hoping that they could provide new design resources for garment pattern design [2]. Modern computer technology enables one to combine art and mathematics closely. The beauty contained in mathematical formulas and theorems is being discovered and utilized by people in the field of art. The rise of mathematical art graphics has given a shot into traditional clothing patterns. Hence, the use of technology for new design pattern creation becomes an important research field of the design industry.

The fractal pattern is a self-similar pattern with infinite fine structure and an embodiment of unpredictable beauty [3]. The use of fractals can create a variety of artistic patterns with high resolution. Fractal based design comprises texture creation, color design, and texture synthesis. Traditional fractal pattern design has some drawbacks such as the inability to efficiently reflect the characteristics of real

scenery and texture. Some work on batik design has been done by Tian G. et al. [4]. Generation of flower and geometric art graphics have been developed to design clothing patterns using a complex dynamic system based on Julia set and L-system [5].

Shape Grammar is another approach used for geometrical design creation. The customary motif is used as the initial shape where distinct rules and spatial relationships are defined to generate new designs using Shape Grammars. The rules are based on Euclidean transformations such as translation, rotation, scale, mirror image, and combination of these transformations. The researchers use this concept in traditional textile designing [6], [7], [8]. These shape grammars and the Fractal design approach produce symmetrical geometrical pattern designs. The salient features of these efforts are summarized in Table 2.

Table 2: Literature pertaining to level II

S.No	PAPER TITLE	PURPOSE	APPLICATION
1	Auto-Generation System Based on Fractal Geometry for Batik Pattern Design [4]	Enriching the diversity of batik patterns	Printing and dyeing industry
2	Research on garments pattern design based on fractal graphics [5]	To incept Creativity in the garment pattern design process and accelerates new design generation using a complex dynamic system based on Julia set and L-system.	Design of silk scarves and garment fabric patterns
3	Geometric Shapes Generation in Songket Designs Using Shape Grammar [6]	Shape Grammar based on Euclidean transformation in generating new and innovative designs for songket fabric	Generating new designs in traditional motifs can be scientifically obtained using shape grammar applications
4	A study of Fractal Patterns for the Textile Design of the Fashion Design [9]	Escape time algorithm is used to generate fractal patterns for the textile design.	Design of textile and art cloth patterns
5	Textile pattern design based on multi-rules L-system [10]	Generation method of multi-rules L-system fractal image and innovation in production rules.	Bedding, Curtain, Clothing, etc. The patterns can be directly printed by the inkjet printing machine.

2.3 Literature pertaining to Level III

Keyword Based Image Retrieval (KBIR) uses textual annotations to describe the whole image or its parts. When the details of the objects are not well known or when there is a lack of precision in keywords the results may be vague. This is due to the huge subjectivity of annotations and a large dictionary of

keywords that a user may use for the same objects [11]. If an annotation is to be done based on keywords only, the retrieval becomes subjective to the user who annotates. Some researchers have experimented with some improved approaches like using Inverted file indexing [12] and using Convolution Neural Networks to match large-scale clothes style and pattern with comprehensive annotation [13].

At times, it is not easy to annotate what the designer has designed. It would be helpful if the design that he designed either fully or partly be given as a query and if designs similar to his content are retrieved from the database and ordered in a relevant manner. The Content-Based Image Retrieval (CBIR) algorithms use the information present in the image to perform queries. These algorithms can be categorized mainly in two types: low-level and high-level.

Low-level CBIR algorithms retrieve images using primitive features such as color, texture, shape, or the spatial location of elements for the whole image. This type of retrieval is useful in small and specialized domains. Statistical image features may be used. These may include color moments, color and image segmentation [14], color correlogram, a different moment and entropy, a spatial domain image representation, curvelets [15], [16], [17], wavelets, a bag of words histogram, different MPEG-7 descriptors (e.g. color, shape, and texture descriptors) [18], etc. Since the features describe the whole image, the low-level CBIR results are adequate for the queries to find similar images. Low-level fusion approaches are used combining color, texture, and spatial features in various ways [19], [20], [21]. However, the low-level algorithms may not be efficient if a user tries to obtain images with the same object but containing different backgrounds.

The high-level CBIR algorithms are based on semantic features like emotions, objects, events, or activities that are more suitable for those situations. Their main idea is to separate objects between background and other parts of the image. To extract regions, methods based on e.g., color thresholds, moment-based local operators, fuzzy patterns recognition, or graph etc., may be used. Most often the region extraction method is used [22]. The key drawback of the region-based algorithms is its dependency on the query image which requires storing many details. Some researchers have proposed improved approaches based on halftoning based block truncation coding for indexing and retrieval of compressed images [23] and Deep Supervised hashing for fast retrieval [24]. A. Nasri et al. [25] have proposed a motif detection method for periodic Islamic patterns based on Autocorrelation function and

genetic algorithm with 95.1% accuracy. A.Y Wicaksono et al. [26] offer a batik motif image classification system using the CNN method with new network architecture developed by combining GoogLeNet and Residual Networks named IncRes. The system can be used to classify the batik image motif with 70.84% accuracy.

Table 3: Literature pertaining to level III

S. No	References	Approach	Database	Retrieval Results	Limitations
1	[14]	Image Segmentation using EM Clustering Algorithm estimated GMM parameter. Color:RGB, HSV, CIELab	Ancient Designs extracted from Archaeological / Historical Textiles.	Retrieval is Visually shown	Subjective evaluation
2	[15]	Texture: Gabor, LBP, Curvelet Classifier: SVM	Any Image Dataset is taken	Accuracy:78.2 %	Accuracy not good
3	[16]	4 co-occurrence feature obtained from GLCM (Energy, Entropy, Correlation, Standard Deviation) for texture GMM for each subband and Co-occurrence for specific sub-band	7 databases: Brodatz, Outex_TC_00010, Outex_00012, Outex_TC_00012horizon, Outex_TC_000120t184, Vistex and KTH-TIPS	Retrieval is Visually shown.	Subjective evaluation
4	[17]	Texture: Normalize curvelet features (Scale Energy and standard deviation) into rotation invariance during indexing	Brodatz (1792 in 112 categories), VisTex (1264 in 71 categories)	Retrieval is visually shown	Subjective evaluation
5	[18]	Color: MPEG-7 (SCD and DCD descriptors) on female Muslim fashion.	150 images of Muslim women's clothing (5 classes: R, G, B, Y, Br). Each class: 30 images. Color: SCD, DCD	F-Measure DCD> F-Measure SCD	Not tested on large dataset
6	[19]	Color: Color Moment (mean, S.D and Skewness) Spatial: GFD (Gist Feature Descriptor) (Gabor wavelet filters with multiscale& multi-directions)	FABRIC database Total printed images:700	Avg.precision :86.3% Avg.recall: 53.3%	Not tested on large dataset

7	[20]	Color: RGB, HSV, CIELAB Texture: LDP, NSCT Classifier: ENSEMBLE (KNN, SVM, ELM)	PUBLICLY: https://www.textures.com/category/browse/ USES 150 images	Precision: 99.4% Recall: 98.9% F-measure: 98.1%	Not tested on large dataset
8	[21]	Texture: LBP Human Detection: HOG Hard Negative mining: Train SVM Color: HSV	2 Database (INRIA & MIT) INRIA-2478 positive (L&R Pose) &12180 negative MIT: 509 training &200 test images Extend INRIA dataset:1500 Positive fashion shoots &7000 more initial hard negatives through the internet (Deviant art & Behance.net)	Color retrieval accuracy 90%	Retrieval based on limited features
9	[25]	Motif detection method for periodic Islamic patterns based on Autocorrelation function and genetic algorithm.	166 images of Islamic Geometric Pattern (IGP)	Correct detection Rate:95.1%	Not tested on large dataset
10	[26]	CNN with GoogLeNet and Residual Network name it CNN IncRes	Personal Database Total:7112 batik image, 11 class Training: 6401 images Testing: 711 images	Accuracy: 70.84% Computation Time:733ms	Low Accuracy

2.4 Literature pertaining to Level IV

The adoption of Artificial Intelligence (AI) techniques for the textile industry is in its infancy. A few use cases can however be seen at post-production level in fabric pattern inspection for identifying defects. Cognex VIDI platform [27] of the Cognix company does this by training the system with images of good patterns. Their system learns automatically from these in identifying defects in patterns. Another application of AI is developed by DATACOLOR for matching color changes in the printed fabric from the colors envisaged in the design [28]. Other AI applications covered in the literature are cotton grading, yarn grading, prediction of yarn properties, fabric color fastness prediction, dye recipe prediction, using Artificial Neural Networks (ANN) [29].

Garment manufacturing involves processes such as conceptualization, design development, PPC (Production Planning and Control), spreading, cutting, bundling, sewing, pressing, and packaging. Computer-Aided Design (CAD) systems are used in garment manufacturing for creating designs,

patternmaking, and grading operations. Several attempts have been made by researchers to integrate AI with CAD systems to generate designs automatically [30]. Experienced designers are needed for the appropriate pattern design on different clothing styles. However, the AI system can be used to provide expert knowledge of experienced designers. S.Inui [31] had developed an **AI integrated CAD system** (combination apparel CAD and Genetic Algorithms (GA)) that can be used to search apparel designs that the system users prefer. The search process involves the man-machine interaction cycles, where the user assesses the examples produced by the systems.

Genetic Algorithms which come under the broad area of evolutionary algorithms (EA) are provoked by biological evolutions such as reproduction, mutation, etc. These algorithms start with an initial population of random possible solutions to the problem at hand. The solutions are evaluated based on a fitness function which is the main heart of these algorithms. The domain knowledge has to be carefully fitted into this fitness function as only fittest parents are selected for the reproduction of new children using crossover and/or mutation. This process is repeated until we get the finest solution.

Designing a suitable fitness function is the most crucial step as the usual evaluation is only done by the human mind and no scale exists to measure them quantitatively. As its solution, interactive EA was visualized, where the fitness function is replaced by a human's evaluation. An interaction is created between humans and computers, which has partly solved problems with the genetic algorithm with respect. The advantage of the method is that human is not required to be aware of details, and he is only concerned with output evaluation. For this reason, interactive EAs can be used to solve problems like art and design which are not solved by the traditional EAs easily. Some recent efforts utilizing EAs and interactive EAs for textile design are summarized in Table 4.

Table 4: Some literature pertaining to level IV

S.No	PAPER TITLE	PURPOSE	APPLICATION	Limitations
1	3D Garment design using Interactive Genetic Algorithm and Clustering [32]	IGA and FCM are effective in designing 3D women's swimsuit, and positive results can be seen on the user's fatigue reduction.	3D design on trousers, blouses, dresses, and jackets, etc.	Apparel design not pattern design
2	Genetic Algorithm Approach for Fabric pattern generation in	To create more possible patterns of Nigeria's locally made fabric.	Enhancing the creativity of	Only graphical representation like (circle,

	Textile Industries [33]		designers in the Textile industry.	triangle etc.) are generated
3	Jacquard pattern optimizing in weft knitted fabrics via the interactive genetic algorithm [34]	An Interactive Genetic Algorithm that receives necessary feedbacks from the user & optimizes design by choosing ideal patterns.	To create more beautiful and attractive designs and colors	Manual feedback approach is used
4	A formal approach to the study of the evolution and commonality of patterns [35]	To preserve its cultural artifact, and enriching the diversity of traditional Korean patterns	The finding can be used for other cultural patterns.	Not support the detection of scaled shapes.

3. Proposed Work

The description of the prior art in terms of tools available for Textile designers provided in section 2 gives a fair idea of the state of the art in this domain. Research has been going on for the development of tools/techniques at all levels i.e., level I to level IV. However, as can be seen from the prior art almost no work has been done on the design and development of tools for Indian traditional design forms. Efforts are proposed to be made in this work to fill this gap. Specifically, the following tasks shall be pursued.

1. Designers today have the advantage of the availability of large design databases even in the Open and non-proprietary mode. But such a database is not available for traditional Indian textile designs. An attempt would be made to create a comprehensive and well-annotated database of designs that can be utilized easily by the designers to improve their productivity. The utility of the database would depend considerably on the variety of queries that are supported by the tool. Efforts would be made to create comprehensive indexing schemes to enable the designer to specify high-level queries and obtain relevant designs from the database. Such a database of designs is imperative to trigger innovative ideas to provide a better output than what already exists in the database. These designs would then get added to the database and the cycle of continuous improvement would be set in to continually improve the output produced.
2. Attempts would be made to create a tool that would enable the designers to specify in simple terms through keywords or diagrams the kind of designs they want to see from the database and the software would retrieve what they desire automatically.

We propose to develop a KBIR approach for indexing designs that are annotated based on their art forms, type of cloth used, the production process, color, texture, and so on. Then within each higher form of the classification there can be further sub-categories. Each art form is inspired by mythological characters, nature, etc. Designs can be annotated based on the content of the art form which will facilitate retrieval based on content.

We also propose to develop a CBIR approach by identifying low-level features that can be used to extract the desired designs similar to the query design based on image/content matching. It is well known that pure keywords-based retrievals, as well as Content-based retrievals, have their limitations. Efforts would, therefore, be made to develop a tool that integrates ideas from Keyword-based retrievals and Content-based retrievals for better accuracy in retrieving desired designs.

This would be a very useful tool for the designers and would contribute immensely to the reduction of design cycle time. Small design cycle times are extremely important in the highly competitive markets of today and such a tool would go a long way in enhancing the competitiveness of the designer trainees in the project.

3. Automated textile design generation is a thriving research area with intelligent techniques providing a new impetus to the development of ever more powerful techniques. Attempts would be made to create AI-based tools for the realization of designs from high – level specifications. Evolutionary design is now a well - established field. It is proposed to create tools that speed up the design process enabling the production of full designs from partial and/or high-level specifications of designs provided to the system in an automated / semi-automated manner.

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